



Design of a Lithium Bromide Absorption Refrigeration Demonstration Unit

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Abstract

This project is based on the design and simulation of a Lithium Bromide–Water absorption refrigeration unit. The main purpose of the project is to understand the working of an absorption refrigeration system and study its performance using simulation. In this system, water is used as the refrigerant and Lithium Bromide (LiBr) is used as the absorbent.

The system mainly consists of a generator, condenser, evaporator, absorber, solution pump, expansion valve, and solution heat exchanger. Heat is supplied to the generator, which separates water vapour from the LiBr solution. The water vapour then moves towards the condenser and is converted into liquid. After passing through the expansion valve, it enters the evaporator and produces the required cooling effect. The water vapour is then absorbed by the LiBr solution in the absorber, and the cycle continues.

In this project, a basic mathematical model of the system is developed using mass balance and energy balance. The system is then simulated using suitable simulation software. Different operating conditions such as generator temperature, evaporator temperature, condenser temperature, and LiBr concentration are considered to study their effect on system performance.

The main performance parameter considered in this study is the Coefficient of Performance (COP). The cooling capacity, heat supplied to the generator, and heat rejected from the system are also studied. The simulation results will help in finding suitable operating conditions for the system.

The main aim of this project is to study the LiBr absorption refrigeration

system before developing the actual demonstration unit.

INTRODUCTION

Design and simulation of a lithium bromide absorption refrigeration unit is important to increase the demand for energy-efficient and environment-friendly cooling technology. This project is useful for undergraduate students as it provides an understanding of the absorption refrigeration system.

The system operates using a low-grade heat source instead of high electrical power. This project focuses on the design and performance analysis of a single-effect lithium bromide-water absorption refrigeration system. The system uses water as a refrigerant and lithium bromide as the absorbent, providing an alternative to the conventional vapour-compression refrigeration system.

In the present work, different components are used for proper demonstration. The main components are:

1. Generator
2. Condenser
3. Evaporator
4. Absorber
5. Lithium bromide solution

To obtain the required parameters, various measuring instruments are deployed. Temperature measurements are taken



at the entry and exit points of the cooling chamber and at the condenser side.

Research Gap

Existing studies on lithium bromide–water absorption refrigeration systems mainly focus on commercial-scale systems and individual performance parameters. There is a need for an integrated simulation model of a small-capacity system to analyze the effects of operating conditions on COP, cooling capacity, and crystallization limits. This project aims to address this gap through thermodynamic modeling and parametric analysis without physical fabrication.

PROBLEM IDENTIFICATION

- High electricity consumption in conventional refrigeration systems Conventional vapour-compression refrigeration systems use electrically driven compressors, which consume a large amount of electrical energy. This increases operating costs and creates the need for cooling systems that can operate using heat energy instead of electricity.
- Environmental concerns related to conventional refrigerants Many conventional refrigeration systems use synthetic refrigerants that may contribute to global warming when released into the atmosphere. This creates the need for an alternative system using water as the refrigerant and lithium bromide solution as the absorbent.
- Limited utilization of waste heat and solar energy A large amount of heat is wasted from industrial processes, engines, and solar collectors. Since this low-grade heat can be used to drive absorption refrigeration systems, there is a need to design a unit that demonstrates this possibility.
- Difficulty in understanding absorption refrigeration through theory alone Students often find it difficult to understand the absorption refrigeration cycle using only diagrams, equations, and classroom explanations. A physical demonstration unit is required to show the actual flow of refrigerant and solution, heat transfer, and cooling process.

LITERATURE REVIEWS

Literature Survey:

Akash Jadhav, Devendra Raut, Vilas R. Kalamkar “Review on solar powered H₂O–LiBr absorption cooling systems for sustainable buildings” This review examines solar-powered H₂O–LiBr absorption cooling systems as sustainable alternatives for building air conditioning. The review discusses rooftop installations, building-integrated thermal systems, HVAC integration, system sizing, and economic feasibility, reflecting growing interest in building decarbonization. However, installation costs and system integration remain important challenges. Future research should focus on smart buildings, demand response, hybrid renewable energy systems, and standardized building codes. Overall, solar-powered LiBr–water absorption refrigeration systems offer promising opportunities for sustainable cooling and carbon-neutral buildings. Single-effect, double effect and hybrid H₂O–LiBr absorption systems powered by solar energy.

Single-effect, double effect and hybrid H₂O–LiBr absorption systems powered by solar energy.

- Key configurations suitable for different components such as generator, absorber, evaporator, and condenser.
- Performance analysis using computational models and real-world experiments.
- Geographical and climatic relevance of system deployment.
- Identification of research gaps, technological challenges, and future opportunities.



S.Arunkumar ,R.Ragavendran “Design And Fabrication Of Solar Powered Lithium Bromide Vapour Absorption Refrigeration System”

Solar-powered absorption refrigeration is a sustainable cooling technology that utilizes solar thermal energy to operate a refrigeration system. It is particularly useful for rural areas and decentralized cold storage, where electricity availability is limited. Unlike conventional vapour compression systems, absorption refrigeration can use renewable energy or waste heat, reducing dependence on electrical power and minimizing environmental impacts. The LiBr–water working pair is suitable for air conditioning and cooling applications because of its favourable thermodynamic properties. In the proposed system, solar energy is collected and supplied to a heating coil, while a pump circulates the working solution.

Akash Jadhav, Devendra Raut, Vilas R. Kalamkar “Design and experimental analysis of a shell and tube vapor generator for solar thermal vapor absorption refrigeration” The study investigates the design and experimental performance of a shell-and-tube heat exchanger used as a generator in a low-capacity lithium bromide–water (LiBr–H₂O) absorption refrigeration system. The generator is a critical component because it supplies thermal energy to separate water vapour from the LiBr solution, directly influencing the system’s cooling performance. Unlike previous studies focusing mainly on high-capacity applications.

A generator was designed for a nominal cooling capacity of 0.5 ton of refrigeration (TR) and experimentally tested under different operating conditions. The investigation considered hot-water inlet temperatures of 80–90°C and operating pressures ranging from 0.65 to 0.90 bar, considering the limitations associated with LiBr crystallization. Results indicated that the heat exchanger performed most effectively at an inlet water temperature of 80°C, a flow rate of 3 L/min, and an initial pressure of 0.65 bar. However, vapour generation was highest at 0.90 bar and lowest at 0.65 bar. The proposed configuration was found suitable for absorption refrigeration systems with cooling capacities of approximately 0.16–0.3 TR, demonstrating its potential for small-scale solar-assisted residential cooling applications.

The most explored pairs for refrigerant and absorbent are NH₃-H₂O, LiCl-H₂O and LiBr-H₂O. While other pairs like NH₃-H₂O and LiCl-H₂O are being explored for other specific applications. **Among all the pairs of absorbent and refrigerant, LiBr-H₂O possesses zero global warming potential, and it has no degrading effect on the environment.** In this work, the study parameters are selected by considering a pair of LiBr-H₂O by referring to the available literature.

Azmair Rashid Raiyan,M Muhtasim Uzzaman,M Monjurul Ehsan,Yasin Khan “Exergoeconomic assessment of a novel ejector recompression absorption cycle integrated with flash tank enhanced compression refrigeration cycle: ANN assisted genetic algorithm optimization” This study proposes a novel Injection Compression Ejector Recompression Absorption Refrigeration Cycle (IC-ERAC) to improve the energy efficiency of conventional cascaded absorption–compression cooling systems. The system combines an ammonia–water ejector-enhanced recompression absorption cycle with an R41 flash-tank-enhanced vapour compression cycle. Vapour recompression reduces external heat requirements, while flash-tank vapour injection reduces compressor workload and supports low-temperature cooling. The economic analysis reports a payback period of 3.42 years and an internal rate of return of 31.06%, indicating promising energy and economic performance.

Tausif Ahmada, Md Azharb, M.K. Sinhaa, Md Merajc, Islam Mohammed Mahbulul, Akbar Ahmade “Energy analysis of lithium bromide-water and lithium chloride-water based single effect vapour absorption refrigeration system: A comparison study” The present research article discussed; a detailed energy analysis for single effect vapour absorption refrigeration system using two working pairs Lithium bromide-water (LiBr–H₂O) and Lithium chloride-water (LiCl–H₂O) under different operating climate conditions. The performance parameters of the both the systems like coefficient of performance (COP), solution concentration, heat load at different components and optimum operating generator temperature have been investigated for both the systems. The capacity of the systems is fixed as 300 kW. The present work has been simulated for the evaporator temperatures of 5, 10 and 15 °C while the condenser temperatures of 25, 30 and 35 °C. Result shows, the maximum COP of LiBr–H₂O



system comes out to be in the range of 0.741–0.902, whereas in case of LiCl–H₂O system it is to be in the range of 0.809–0.926. The minimum load at the generator for LiBr–H₂O system is 382.573 kW, while for LiCl–H₂O as 370.787 kW. Comparison shows that the LiCl–H₂O system has better COP and minimum generator load as compared to LiBr–H₂O system, especially at lower evaporator temperatures. The optimum operating generator temperature has been observed 54.56 °C for LiBr–H₂O system and 56.25 °C for LiCl–H₂O system.

J. L. Rodríguez-Munoz, J.S. Pacheco-Cedeno, J. F. Ituna-Yudonago, J.J. Ramírez-Minguela, I. J. González-Hernández “The review investigates LiBr–water absorption refrigeration systems (ARS) using condenser heat recovery to improve system performance”. The proposed heat recovery absorption

refrigeration system (HR-ARS) is compared with a conventional ARS through energy and exergy analyses. Results show that reducing condenser/absorber temperature from 40°C to 30°C increases COP by 5.8%–6.3% and exergy efficiency by 3.7%–9.5%. Increasing evaporator temperature from 5°C to 15°C improves COP by approximately 8%. The HR-ARS achieves around 3% higher COP than conventional ARS. Increasing solution heat exchanger effectiveness reduces total exergy destruction by 3.24%–5.01%. The generator and absorber account for 80%–94% of total exergy destruction.

Yujie Zhou, Lei Pan, Xu Han, Li Sun “**Dynamic modeling and thermodynamic analysis of lithium bromide absorption refrigeration system using Modelica**” (2023) Developed a dynamic simulation model to analyze system performance and improve LiBr absorption refrigeration system design.

Mamadou Sow, Lavinia Grosu “**Energy and Exergy Assessment of a Solar Driven Single Effect H₂O–LiBr Absorption Chiller Under Moderate and Hot Climatic Conditions**” (2025) Experimentally validated a lithium bromide absorption power cycle, demonstrating efficient heat-driven cooling and system feasibility.

J.F. Chen, Y.J. Dai, R.Z. Wang “**Experimental and analytical study on an air-cooled single effect LiBr–H₂O absorption chiller driven by evacuated glass tube solar collector for cooling application in residential buildings**” (2017) A 6 kW solar-powered LiBr–H₂O absorption chiller achieved 65% cooling-load coverage, 0.61 thermal COP, and reduced water consumption.

Zian Haoa, Dehua Caia, Aihua Wua, Yangyang Lina, Qiqi Tian “**Thermodynamic analysis and performance enhancement of a solar driven atmospheric water harvesting system integrating absorption energy storage**” (2026) 125936 Solar-driven atmospheric water harvesting with absorption energy storage produces 2.18–6.01 kg/m²/day clean water efficiently, supporting sustainable freshwater access in arid regions.

Literature Summary

The reviewed literature shows that lithium bromide–water absorption refrigeration systems are an effective alternative to conventional vapour-compression refrigeration systems, especially when low-grade heat sources such as solar energy or waste heat are available. Several studies confirmed that H₂O–LiBr systems can produce cooling with a coefficient of performance generally in the range of 0.6 to 0.9 under suitable operating conditions. Solar-powered LiBr–water absorption systems were found to reduce electricity consumption and operational carbon emissions, making them suitable for sustainable buildings, rural cooling, and decentralized cold-storage applications.



The studies also indicate that system performance strongly depends on generator, absorber, condenser, and evaporator temperatures, as well as solution concentration and heat-exchanger effectiveness. Reducing condenser and absorber temperatures and increasing evaporator temperature generally improve the COP of the system.

Single-effect, double effect and hybrid H₂O–LiBr absorption systems powered by solar energy.

- Key configurations suitable for different components such as generator, absorber, evaporator, and condenser.
- Performance analysis using computational models and real-world experiments.
- Geographical and climatic relevance of system deployment.
- Identification of research gaps, technological challenges, and future opportunities.

Overall, the literature supports the need for a simple, compact, and educational lithium bromide–water absorption refrigeration demonstration unit to help students understand the working principle, component functions, and effect of operating conditions on system performance. Among all the pairs of absorbent and refrigerant, LiBr-H₂O possesses zero global warming potential, and it has no degrading effect on the environment. In this work, the study parameters are selected by considering a pair of LiBr-H₂O by referring to the available literature.

RESEARCH METHODOLOGY

Proposed System

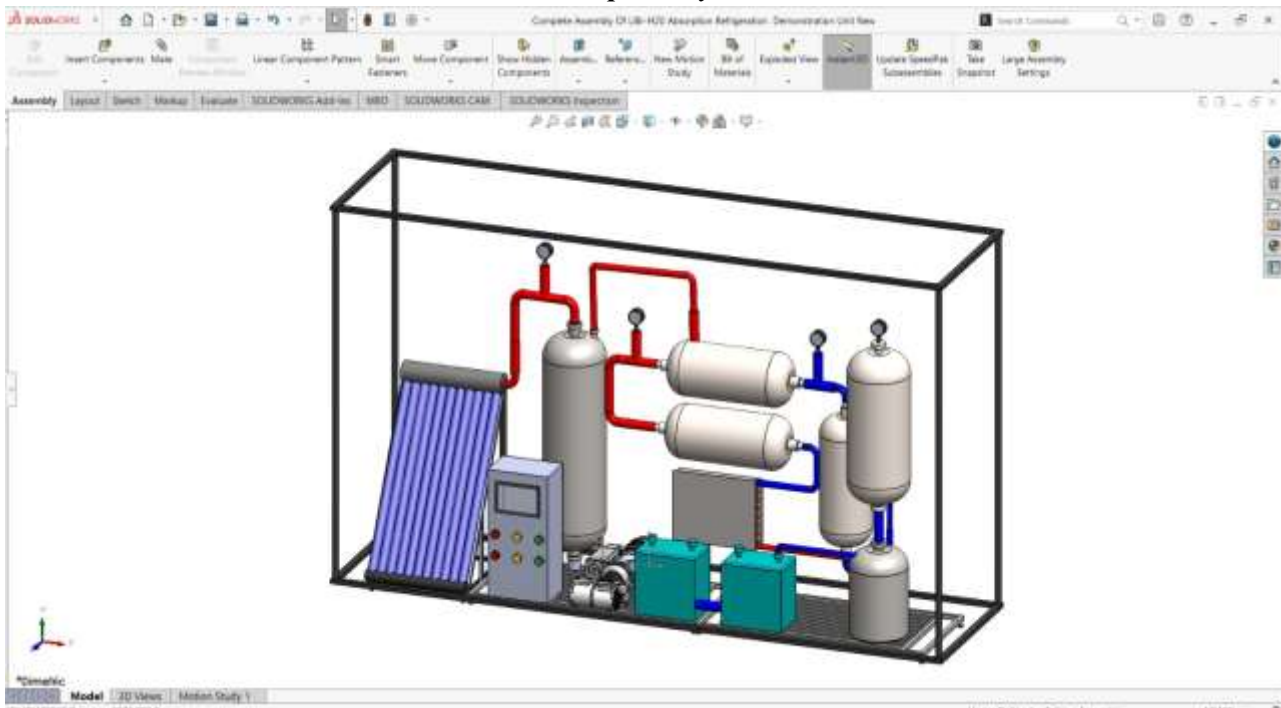


Figure 1. Proposed System

The proposed system is a **Lithium Bromide–Water Absorption Refrigeration Demonstration Unit** designed in SOLIDWORKS for simulation and educational analysis. It consists of a solar thermal collector, hot-water storage tank, generator, absorber, condenser, evaporator, solution heat exchanger, pumps, and connecting pipelines. Solar energy supplies heat to the generator, where water refrigerant separates from the lithium bromide solution. The refrigerant undergoes condensation and evaporation to produce cooling, while the absorber recovers the refrigerant vapor into the solution. Temperature and pressure gauges, a control panel, and a vacuum pump are included to represent system



monitoring and vacuum maintenance.

ADVANTAGES AND APPLICATIONS

Advantages

- It can operate using low-grade heat sources such as solar energy, waste heat, exhaust gases, or hot water, thereby reducing dependence on electricity.
- The lithium bromide solution is non-volatile, which makes the system safer and more stable during operation.
- From literature studies, it is observed that H₂O-LiBr and H₂O-LiCl are preferred choices for absorption chiller. Though H₂O-LiCl shows better thermodynamic and economic performance than H₂O-LiBr, its practical application is limited due to frequent crystallization problems. Thus, H₂O-LiBr is preferred for practical application. Furthermore, H₂O-LiBr has the following benefits over its competitor NH₃-H₂O.
- H₂O-LiBr system is eco-friendly.
- H₂O-LiBr system has higher value of COP_{th} than NH₃-H₂O system.
- The generator temperature requirement for a single effect H₂O-LiBr system (70–90°C) is lower than NH₃-H₂O system (90–180 °C). Thus, H₂O-LiBr units can be easily configured with low-temperature collectors such as FPC and ETC. The H₂O-LiBr system can be suitable for low-irradiance areas.

Applications

- Building air-conditioning systems, particularly in hotels, hospitals, offices, malls, and large commercial buildings.
- Solar-powered cooling systems, where solar thermal collectors provide the heat required for the generator.
- Waste-heat recovery systems in industries, where exhaust heat from furnaces, engines, turbines, or process equipment is used for cooling.
- Cold-storage and food-preservation applications, especially in rural or remote areas where electricity supply is limited.
- Chilled-water production for central air-conditioning and process-cooling requirements.
- Cogeneration and tri-generation systems, where electricity, heating, and cooling are produced from the same heat source.

CONCLUSION

The design of a lithium bromide–water absorption refrigeration demonstration unit provides an effective way to understand the working principle of absorption refrigeration systems. The proposed unit uses water as the refrigerant and lithium bromide solution as the absorbent, and it consists of the main components such as the evaporator, absorber, solution heat exchanger, generator, condenser, and solution pump. The study shows that cooling can be produced using low-grade heat energy instead of electrical power, making the system suitable for waste-heat recovery and solar-powered applications.

The thermodynamic design of the unit helps in determining the operating temperatures, pressures, heat loads, solution circulation ratio, and coefficient of performance. The performance of the system mainly depends on the generator, absorber, condenser, and evaporator temperatures, as well as the concentration of the lithium bromide solution. A properly designed demonstration unit allows students to observe the flow of refrigerant and solution, understand the function of each component, and study the effect of operating conditions on system performance.



FUTURE SCOPE

- The simulation model can be further developed to analyse the performance of the lithium bromide–water absorption refrigeration system under different operating conditions, such as varying generator, condenser, absorber, and evaporator temperatures.
- The model can be extended to study the effect of solution concentration, solution circulation ratio, heat-exchanger effectiveness, and heat-source temperature on cooling capacity and coefficient of performance.
- Solar thermal energy can be included in the simulation by modelling solar collectors, storage tanks, and varying solar radiation conditions throughout the day.
- Waste-heat sources from engines, industrial processes, or exhaust gases can be simulated to evaluate the feasibility of waste-heat-driven absorption refrigeration systems.

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